Mechanism of MR Brain Signal Increase in Hyperoxia

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INTRODUCTION

Brain MR signal increases have been observed on human volunteers breathing 100% O2 (1, 2, 4). Increases were observed mainly in gray matter. To determine the hemodynamic events contributing to the signal change we performed experiments which assessed blood flow, oxygenation, and volume changes.

HYPOTHESES FOR MR SIGNAL INCREASE

Increased venous Oxyhemoglobin due to dissolved oxygen in plasma If the utilization of oxygen by tissue is partially met by dissolved oxygen in plasma, oxyhemoglobin in the venous side will increase while deoxyhemoglobin will decrease, leading to an increase of signal.

A. Villringer et al. (3) showed that infrared studies of human volunteers breathing 100% O2 demonstrated an increase of oxyhemoglobin signal and a decrease of deoxyhemoglobin signal.

Reduced blood volume caused by 100% Oxygen breathing A decrease of blood volume and the amount of deoxyhemoglobin per voxel would lead to an enhancement of MR signal. To check this hypothesis, we injected rabbits with T2* weighted contrast agents such as iron oxide aggregates and measured signal change between breathing 100% O2 and air.

Flow change due to the breathing of 100% O2 Unlike CO2, Oxygenation is not known to cause large CBF increase. In fact, Rostrup et al (4) measured a drop of through plane velocities at the internal carotid and vertebral arteries. We tested the flow properties of breathing oxygen with the use of a flow sensitive T1 weighted spin echo sequence.

METHODS

All experiments were performed on a 1.5 Tesla GE Signa clinical system retrofitted with echo planar imaging (EPI) from Advanced NMR. To measure blood volume change, iron oxide contrast agents with half life of several hours (MION and PION) were used in the O2 breathing studies. Four New Zealand white rabbits weighing 2-3 kg were anesthetized, tracheostomized and ventilated alternately either with air and 100% O2 or with air ad 5% CO2. T2 weighted spin echo sequece (TR=3s, TE=75ms) was used to study change in oxyhemoglobin and deoxyhemoglobin. To measure flow change, T1 weighted inversion recovery spin echo sequence (TR=3sec, TI=1sec, TE=20ms) was used. Rabbits were studied with and without contrast agents.

RESULTS

Without the use of contrast agents, both 100% O2 and 5% CO2 breathing demonstrated a rise of MR signal in the T2 weighted sequence. With the application of a high dose of paramagnetic contrast agent, signal always increased with breathing 100% O2, whereas signal decreased below baseline with breathing 5% CO2 (Fig.1).

In breathing100% O2, the minor increase in MR signal with T1 wighted (flow) sequence was much smaller than what was observed in the T2 wieghted spin echo sequence. This differes from what is observed in functional MR studies where T1 weighted signal increases are normally larger than T2 weighted signal increases at 1.5 Tesla.

DISCUSSION and CONCLUSION

The causes of MR signal increases in the breathing of 100% O2 have been explored. T1 weighted results suggest that flow increase is small. The constant rise of T2 weighted MR signal even at the presence of a high dose of paramagnetic contrast agent suggests there might be a drop of blood volume such that the oxyhemoglobin effect is enhanced by the reduction of T2* weighted contrast agents in the voxels. In breathing O2, we are observing a different type of physiologic MR contrast that is likely different from that involved with brain activation induced MR signal changes. The potential of O2 being a novel contrast agent is being explored.

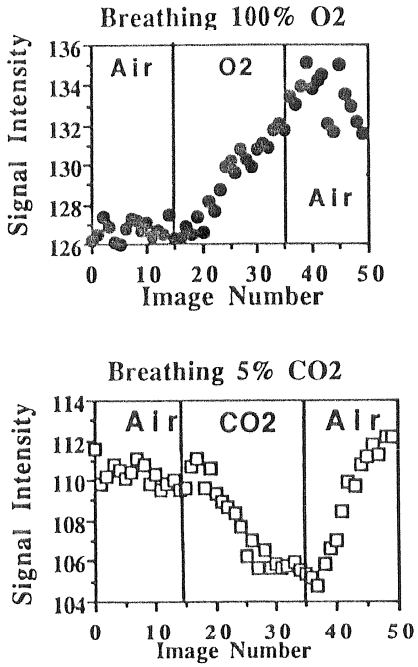

FIG. 1
MR Signal Response to O2 and CO2 with injection of Iron Oxide. Dosage: 20 Mg of PION per Kg

REFERENCES

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